

## CLAIMS

1. A method of matching service requests for a switch arrangement to connect traffic from first sub-elements providing at least ingress to the switch arrangement to  
5 second sub-elements providing at least egress from the switch arrangement, the switch arrangement comprising a number  $N$  of first elements comprising logical associations of the first sub-elements, each logical association of first sub-elements comprising a number  $L_1$  of said first sub-elements, the switch arrangement comprising a number  $ML_2$  of said second sub-elements, each of the  $L_1$  first sub-elements being capable of generating a  
10 service request for traffic arriving via the first sub-element to be connected to at least one of said  $ML_2$  second sub-elements, wherein the method comprises:
- for each of said  $N$  logical associations, aggregating service requests from all  $L_1$  first sub-elements to each of the  $ML_2$  second sub-elements;
  - resolving contention for said service requests from said  $N$  logical associations to  
15 one or more of said second-sub-elements; and
  - for each of said  $N$  logical associations, resolving contention between the  $L_1$  first sub-elements and said  $ML_2$  second sub-elements.
2. A method as claimed in claim 1, wherein said first sub-elements and said second  
20 sub-elements are bi-directional.
3. A method as claimed in claim 1, wherein said first sub-elements provide input to the switch arrangement and said second sub-elements provide output from the switch arrangement.
- 25
4. A method of matching service requests for a switch arrangement to connect traffic from the inputs of the switch arrangement to the outputs of the switch arrangement, the switch arrangement comprising a number  $N$  of logical associations of the inputs, each logical association of inputs comprising a number  $L_1$  of inputs arranged to provide at least  
30 ingress to the switch arrangement and a number  $ML_2$  of outputs arranged to at least provide egress from said switch arrangement, wherein the  $L_1$  inputs are arranged to generate service requests for traffic to be connected to the  $ML_2$  outputs, wherein the method comprises:
- for each of said  $N$  input associations, aggregating service requests from all  $L_1$   
35 inputs to each of the  $ML_2$  outputs;

resolving contention for said service requests from all N input associations to one or more of said outputs; and

for each of said N input associations, resolving contention between the  $L_1$  inputs and said  $ML_2$  outputs.

5

5. A matching method for a number N of first elements, each first element arranged to at least provide ingress to a switch arrangement, each of the first N elements comprising a number  $L_1$  of first sub-elements, the switch arrangement having a number  $ML_2$  of second sub-elements arranged to at least provide egress from said switch arrangement, and wherein each of the first  $L_1$  sub-elements is capable of conveying a service request for at least one of said second sub-elements  $ML_2$ , wherein the method comprises:

for each of said N first elements, aggregating service requests from all  $L_1$  first sub-elements to each of the  $ML_2$  second sub-elements;

15 resolving contention for said service requests from all N first elements to one or more of said second  $ML_2$  sub-elements; and

for each of said N first elements, resolving contention between the  $L_1$  sub-elements and said second  $ML_2$  sub-elements.

20 6. A matching method as claimed in claim 5, wherein the step of resolving contention between the  $L_1$  sub-elements and said second  $ML_2$  sub-elements is performed in parallel for each said first element.

7. A matching method as claimed in claim 5 or 6, wherein the  $ML_2$  second sub-elements of the switch arrangement are provided as a number M of second elements, each of said M second elements being associated with a number  $L_2$  of second sub-elements.

8. A matching method as claimed in any one of claims 5 to 7, wherein each sub-element is capable of generating at least one said service request.

9. A matching method as claimed in any one of claims 5 to 8, wherein said first sub-elements and said second sub-elements are bi-directional and provide both ingress and egress from the switch fabric.

35

10. A matching method as claimed in claim 9, wherein said first sub-elements comprise said second sub-elements.
11. A matching method as claimed in any one of claims 5 to 9, wherein said first sub-  
5 elements and said second sub-elements are unidirectional and said first sub-elements provide ingress and said second sub-elements provide egress from the switch arrangement.
12. A matching method as claimed in any one of claims 5 to 11, wherein said first  
10 and second sub-elements comprise ports in the switch arrangement and said first elements comprise aggregations of said first sub-elements.
13. A matching method as claimed in any one of claims 8 to 11, wherein said first  
15 and second sub-elements comprise ports in the switch arrangement, said first elements comprise aggregations of said first sub-elements and said second elements comprise aggregations of said second sub-elements.
14. A matching method as claimed in any one of claims 5 to 13, wherein said switch  
20 arrangement comprises an input queued cell switch and said service requests comprise requests for transmitting a service information rate from one of said first sub-elements to at least one of said second sub-elements.
15. A matching method as claimed in any one of claims 5 to 13, wherein said switch  
25 arrangement comprises an input queued cell switch and said service requests comprise requests for transmitting at least one cell from one of said first sub-elements to at least one of said second sub-elements.
16. A matching method as claimed in any one of claims 5 to 13, wherein said switch  
30 arrangement comprises an input queued packet switch and said service requests comprise requests for transmitting a service information rate from one of said first sub-elements to at least one of said second sub-elements.
17. A matching method as claimed in any one of claims 5 to 13, wherein said switch  
35 arrangement comprises an input queued packet switch and said service requests comprise requests for transmitting at least one packet from one of said first sub-elements

to at least one of said second sub-elements.

18. A matching method as claimed in claim 16, wherein the packets have a fixed-length and comprise cells and wherein said packet switch is an input queued cell switch  
5 arranged to switch fixed-length cells, and said service requests comprise requests for transmitting one or more fixed-size cells from one of said first sub-elements to one or more of said second sub-elements.

19. A matching method as claimed in claim 17, wherein the packets have a fixed-  
10 length and comprise cells and wherein said packet switch is an input queued cell switch arranged to switch fixed-length cells, and said service requests comprise requests for transmitting a service information rate from one of said first sub-elements  $L_1$  to one or more of said second sub-elements  $L_2$ .

15 20. A method as claimed in any previous claim, wherein said switch arrangement comprises a circuit based switch and said service request comprises a request for at least one of the following:

- a connection in the circuit-based switch;
- a wavelength channel in the circuit-based switch
- 20 a bandwidth in the circuit-based switch;
- a service information rate in the circuit-based switch;
- a bit rate in the circuit-based switch.

21. A method as claimed in claim 20, wherein said circuit based switch comprises a  
25 switch incorporating one or more of the following switching technologies :

- time-domain switching technology;
- frequency domain switching technology;
- wavelength domain switching technology;
- space domain switching technology.

30

22. A method as claimed in any previous claim, wherein the switch arrangement comprises a network, and wherein said elements comprise aggregations of network terminals or nodes and said sub-elements comprise network terminals or nodes.

35 23. A method as claimed in any previous claim, wherein the switch arrangement

comprises an arrangement of inter-connectable sub-networks, where said elements comprise sub-networks and said sub-elements comprise network terminals or nodes.

24. A method as claimed in claim 23, wherein said network is an optical network.

5

25. A method as claimed in claim 23, wherein said a sub-network comprises at least one of the following:

- a circuit switch;
- a cell switch;
- 10 a packet switch;
- an optical switch;
- a circuit-switched network;
- a cell-switched network;
- a packet-switched network.

15

26. A method as claimed in any one of claims 5 to 26, wherein elements become sub-elements with respect to elements in a higher layer of matching.

27. A method as claimed in any one of claims 5 to 27, wherein multiple layers of  
20 matching are performed in a hierarchy of matching levels.

28. A method as claimed in any one of claims 5 to 27, wherein the method of matching comprises:

- 25 firstly, aggregating service requests to the highest level of the matching hierarchy, and
- secondly, resolving contention for said service requests at the highest level of the matching hierarchy, and
- thirdly, resolving contention in turn down through the matching levels to the lowest level of matching.

30

29. A matching method for a switch arrangement comprising a plurality N of input elements, each input element comprising a plurality ( $L_1$ ) of input sub-elements, and a plurality M of output elements, each output element comprising a plurality  $L_2$  of output sub-elements, the matching method comprising the following steps:

35 performing a first matching across the switch fabric for each of the plurality of N

input elements and the  $ML_2$  sub-elements by performing the steps of:

summing a number of requests from each of the  $L_1$  sub-elements of the input element;

generating a first  $N \times ML_2$  request matrix;

5 matching the first request matrix to generate a first matrix of accepted requests; and

performing a second matching across the switch fabric for each of the  $N$  input elements by performing the steps of:

10 generating  $N$  asymmetric second  $L_1 \times ML_2$  matrices, one for each of the  $N$  input elements; and

matching each of the  $N$  asymmetric second matrices to generate  $N$  second matrices of accepted requests; and

generating a  $NL_1 \times ML_2$  matrix of accepted requests from the first  $N \times ML_2$  matrix of accepted requests and the  $N$  second  $L_1 \times ML_2$  accepted request matrices.

15

30. A matching method as claimed in claim 29, wherein the  $NL_1 \times ML_2$  matrix of requests is symmetric.

20 31. A matching method as claimed in claim 29, wherein  $L_1$  is equal to  $L_2$  and  $N$  is equal to  $M$ .

32. A matching method as claimed in any one of claims 5 to 31, wherein a said sub-element comprise one of the following:

25 a port of a switch;  
a port of a switching network;  
a wavelength channel in an optical network;  
a node in an optical ring network;  
a terminal in an unamplified passive optical network;  
a terminal in an amplified passive optical network.

30

33. A matching method as claimed in claim 32, wherein the switch arrangement comprises at least one of the following:

35 a packet switch arrangement;  
a packet switch arrangement capable of switching fixed-length packets;  
a cell switching arrangement;

- a cell switching arrangement capable of switching packets;
- a circuit switching arrangement;
- a circuit switching arrangement capable of switching connections;
- a circuit switching arrangement capable of switching time slots;
- 5 a circuit switching arrangement capable of switching wavelength channels.

34. A matching method as claimed in any one of claims 5 to 33, wherein said first sub-elements and said second sub-elements are each uni-directional and said first sub-elements provide ingress and said second sub-elements provide egress from the switch fabric.

35. A matching method as claimed in any one of claims 5 to 34, wherein the sub-elements comprise ports, and the matching updates the pointers to input ports according to the following rule:

$$15 \quad p_{out} = 1 + [(LN - P_{in} + k)_{mod LN}] \text{ and}$$

the output ports are updated according to the following rule:

$$p_{in} = 1 + [(LN - P_{out} + k)_{mod L}].$$

36. A matching method as claimed in any one of claims 5 to 34, wherein the sub-elements comprise ports, and the matching updates the pointers to input ports according to the following rule:

$$20 \quad p_{out} = 1 + [(LN - P_{in} + k)_{mod LN}] \text{ and}$$

the output ports are updated according to the following rule:

$$25 \quad p_{in} = 1 + [(m - P_{out} + k)_{mod L}]$$

37. A matching method as claimed in any previous claim, wherein a multicast matching scheme is implemented.

38. A matching method as claimed in any previous claim, wherein the  $ML_2$  output sub-elements are grouped first into  $M$  groups of  $L_2$  sub-elements, and matching is performed first at the group level between the  $N$  groups of  $L_1$  input sub-elements and the  $M$  groups of  $L_2$  output sub-elements, and then, for each of the  $N$  groups of  $L_1$  input sub-elements, between the  $L_1$  individual input sub-elements and the  $M$  groups of  $L_2$  output sub-elements.

39. A matching method for a number  $N$  of first elements, each first element arranged to at least provide ingress to a switch arrangement, each of the first  $N$  elements comprising a number  $L_1$  of first sub-elements, the switch arrangement having a number  $ML_2$  of second sub-elements arranged to at least provide egress from said switch arrangement, and wherein each of the first  $L_1$  sub-elements is capable of conveying a service request for at least one of said second sub-elements  $ML_2$ , wherein the  $ML_2$  sub-elements are grouped into  $M$  aggregations of  $L_2$  sub-elements, and the method comprises:

- 10 firstly, for every one of the  $N$  first elements, aggregating service requests from all  $L_1$  first sub-elements to each of the  $M$  aggregations of  $L_2$  second sub-elements, and
- secondly, resolving contention for said service requests from all  $N$  first elements to one or more of said  $M$  aggregations of  $L_2$  second sub-elements, and
- thirdly, for each first element, resolving contention between the  $L_1$  sub-elements and said  $M$  aggregations of  $L_2$  second sub-elements.

15

40. A switch arrangement, the switch arrangement having number  $N$  of first elements, each first element arranged to at least provide ingress to a switch arrangement, each of the first  $N$  elements comprising a number  $L_1$  of first sub-elements, the switch arrangement having a number  $ML_2$  of second sub-elements arranged to at least provide egress from said switch arrangement, and wherein each of the first  $L_1$  sub-elements is capable of conveying a service request for at least one of said second sub-elements  $ML_2$ , wherein said service requests are conveyed by performing a matching method which comprises:

- 25 for each of the  $N$  first elements, aggregating service requests from all  $L_1$  first sub-elements to each of the  $ML_2$  second sub-elements, and
- resolving contention for said service requests from all  $N$  first elements to one or more of said second  $ML_2$  sub-elements, and
- for each of the  $N$  first elements, resolving contention between the  $L_1$  sub-elements and said second  $ML_2$  sub-elements.

30

41. A switch arrangement as claimed in claim 40, wherein said matching method is as claimed in any one of claims 5 to 39.

42. A network including a switch arrangement as claimed in any one of claims 40 or 41.



43. A suite of at least one computer programs arranged when executed to implement steps in a method according to any one of claims 1 to 39.

44. A suite of at least one computer programs as claimed in claim 43, wherein at least one program is arranged to be implemented by software running on a suitable computational device.

45. A suite of at least one computer programs as claimed in claim 43 or 44, wherein at least one program is arranged to be implemented by suitably configured hardware.

46. A scheduler for a switching arrangement, the scheduler arranged to perform a scheduling process, the scheduling process comprising:  
a matching method as claimed in any one of claims 1 to 39; and  
a channel assignment process.

47. A matching method for a multi-stage switch arrangement having a plurality of logically associated inputs and a plurality of outputs, wherein the matching method comprises the steps of:

for each logical association of inputs, aggregating service requests from every one of the inputs which form said logical association ;

resolving contention for said aggregated service requests between all of the logical associations to the outputs of the switch arrangement; and

repeating the above steps in the matching method within each logical association for a subset of the inputs forming each said logical association until contention is resolved between the individual inputs of the switch arrangement and the outputs of the switch arrangement.

48. A matching method as claimed in claim 47, wherein in each repetition, the number of inputs-forming the logical association is reduced until each logical-association of a sub-set comprises a single input to the switch arrangement, said aggregated service requests comprise a single service request, whereby contention is resolved between each input of the switch arrangement and each output of the switch arrangement.

49. A method as claimed in claim 47 or 48, wherein each step resolving contention between the outputs of the switch arrangement comprises resolving contention between a

logical association of inputs and a logical association of outputs having the same number of inputs .

50. A matching method as claimed in claim 47 to 49, wherein said multi-stage switch  
5 arrangement comprises a plurality of switching stages, at least one switching stage comprising:

a plurality of switches which logically associated into different sets of switches, each set of switches being logically associated with one of said logical associations of inputs of the switch arrangement, wherein each set of logically associated switches  
10 operate only on the inputs of the switch arrangement with which they are logically associated, the switch arrangement further comprising a global spatial switching stage arranged to receive traffic derived from any of the inputs of the switch arrangement via any logically adjacent sets of said switches.

15 51. A matching method as claimed in claim 47 to 50, wherein said multi-stage switch arrangement comprises a plurality of switching stages, at least one switching stage comprising:

a plurality of switches which logically associated into different sets of switches, each set of switches being logically associated with one of said logical associations of  
20 outputs of the switch arrangement, wherein each set of logically associated switches operate only to provide output to the outputs of the switch arrangement with which they are logically associated.

52. A multi-stage switch arrangement arranged to switch time-slotted traffic  
25 segments, the switch arrangement comprising:

a plurality of switching stages including a spatial switching stage arranged to receive traffic which has been switched by at least one switching stage logically adjacent to the input of spatial switching stage, the spatial switching stage being further arranged to output to at least one switching stage logically adjacent to its output,

30 each of said at least one switching stage logically adjacent to the input of the spatial switching stage comprises a plurality of input aggregation switching stages, each aggregation switching stage being logically associated with a subset of the inputs of the switch arrangement,

each of said at least one switching stage logically adjacent to the output of the  
35 spatial switching stage comprises a plurality of output aggregation switching stages, each

output aggregation switching stage being logically associated with a subset of the outputs of the switch arrangement,

the mutli-stage switch being further arranged to implement suitable control means to enable the time-slotted traffic to be matched according to the matching method as  
5 claimed in claim 47.